

19. The capacitive transducer of Claim 5, further including: electrical circuit means for applying electrical drive pulses to said drive plates, said pulses having a frequency F, and a pulse width T of approximately $1/F$ divided by the total number of drive plates, said drive pulses being grouped into one main channel per operative upper/lower drive plate pair, each main channel consisting of two sub-channel pulses, one sub-channel pulse operative on each drive plate, with said main channels being multiplexed to sequentially apply said pulses to said drive plates with said main channels being spaced apart in time by approximately the pulse width T, and said two sub-channel signals of the active main channel being applied simultaneously to the top/bottom drive plate pair;

sampling means for synchronously demodulating the signal on the pickup plate into one channel per drive plate pair, each channel consisting of two sub-channel signals, one for each drive plate;

timing means for controlling said sampling means such that each first sub-channel is sampled during the time period that the drive pulse is applied to the corresponding drive plate and each second sub-channel is sampled after the drive pulse corresponding to that drive plate has ended, and before the drive pulse corresponding to the next channel is applied;

storage means for each sub-channel; and

differential amplifier means to convert each of the two sub-channel signal pairs into single main channel signals.

20. The capacitive transducer of Claim 19, wherein said main channel signals generated by said differential amplifier means constitutes the outputs of the transducer.

21. The capacitive transducer of Claim 19, wherein said upper drive plates comprise four plates and said lower drive plates comprise four plates, further comprising:
electrical circuit means summing all four main channel signals together, said summed signal constituting the Z-axis output signal;

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electrical circuit means generating the difference of two of said main channels, said difference signal constituting the X-axis output signal; and

electrical circuit means generating the difference of the two main channel signals not used to generate the X-axis output, said difference signal constituting the Y-axis output signal.

22. The capacitive transducer of Claim 19, wherein each of said main channel signals generated by said differential amplifier means are connected to feedback circuit means which produce feedback signals which control the amplitude of the drive plate pulses in response to displacement of the pickup electrode, such that the induced voltage on the pickup electrode is forced to zero, and the feedback signals generated by said feedback circuit means are proportional to the displacement of the pickup plate.

23. The capacitive transducer of Claim 22, wherein said feedback signals constitute the outputs of the transducer.

24. The capacitive transducer of Claim 22, wherein said upper drive plates comprise four plates and said lower drive plates comprise four plates, further comprising:
electrical circuit means summing all four feedback signals together, said summed signal constituting the Z-axis output signal;

electrical circuit means generating the difference of two of said feedback signals, said difference signal constituting the X-axis output signal; and

electrical circuit means generating the difference of the two feedback signals not used to generate the X-axis output, said difference signal constituting the Y-axis output signal.

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25. In an optical microscope apparatus having a sample stage providing X-Y motion, focusing means providing Z-axis motion and a multi-position objective turret containing one or more optical objectives, the improvement comprising:

means for multi-axis force and/or displacement measurement including a multidimensional transducer having, the transducer of claim 5, probe tip means for transmitting force and/or displacement between said transducer and a sample.

26. In an optical microscope apparatus having a sample stage providing X-Y motion, focusing means providing Z-axis motion and a multi-position objective turret containing one or more optical objectives, the improvement comprising:

means for multi-axis force and/or displacement measurement including a multidimensional transducer having, the transducer of claim 19, probe tip means for

transmitting force and/or displacement between said transducer and a sample.

27. In an optical microscope apparatus having a sample stage providing X-Y motion, focusing means providing Z-axis motion and a multi-position objective turret containing one or more optical objectives, the improvement comprising:

means for multi-axis force and/or displacement measurement including a multidimensional transducer having, the transducer of claim 20, probe tip means for transmitting force and/or displacement between said transducer and a sample.

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28. In an optical microscope apparatus having a sample stage providing X-Y motion, focusing means providing Z-axis motion and a multi-position objective turret containing one or more optical objectives, the improvement comprising:

means for multi-axis force and/or displacement measurement including a multidimensional transducer having, the transducer of claim 21, probe tip means for transmitting force and/or displacement between said transducer and a sample.

29. In an optical microscope apparatus having a sample stage providing X-Y motion, focusing means providing Z-axis motion and a multi-position objective turret containing one or more optical objectives, the improvement comprising:

means for multi-axis force and/or displacement measurement including a multidimensional transducer having, the transducer of claim 22, probe tip means for transmitting force and/or displacement between said transducer and a sample.

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30. In an optical microscope apparatus having a sample stage providing X-Y motion, focusing means providing Z-axis motion and a multi-position objective turret containing one or more optical objectives, the improvement comprising:

means for multi-axis force and/or displacement measurement including a multidimensional transducer having, the transducer of claim 23, probe tip means for transmitting force and/or displacement between said transducer and a sample.

31. In an optical microscope apparatus having a sample stage providing X-Y motion, focusing means providing Z-axis motion and a multi-position objective turret containing one or more optical objectives, the improvement comprising:

means for multi-axis force and/or displacement measurement including a multidimensional transducer having, the transducer of claim 24, probe tip means for transmitting force and/or displacement between said transducer and a sample.

32. A method of performing a micro-mechanical test on a sample by means of the apparatus of Claim 25, the test consisting of the steps of:

placing the sample on the microscope stage,

locating the feature or region to be tested using the optical objective,

rotating the turret to engage the precision multi-dimensional capacitive transducer,

and

moving the microscope stage and/or focus means to apply the desired force and/or displacement while recording said force and/or displacement.

33. An instrument for providing high resolution tribological properties testing of magnetic recording head sliders and disks, the instrument comprising:

a precision multi-dimensional capacitive transducer,

a load stem and mounting bar attached to said transducer, said mounting bar being of the proper length to position the head slider being tested directly under the load stem of the transducer when the slider suspension is attached to the mounting bar,

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means for moving the disk relative to the slider in at least one direction in the plane of the disk,

means for applying a normal force between the slider and the disk, and

means for recording and/or displaying the normal force and the force in at least one direction in the plane of the disk.

34. The transducer of claim 17 wherein the spring end proximate said spacer means is wider than the main portion of said spring, and extends for a distance of at least $\frac{1}{4}$ of the main width of said spring before contacting the spacers.

35. The transducer of Claim 34 wherein the spacers and center electrode structure includes additional support means about the fixed end of the springs.

36. A precision Multi-dimension capacitive transducer comprising:

a pickup electrode containing six faces said faces operatively grouped into

three pairs, the two faces within each pair being parallel with each other and the faces of each pair being orthogonal with each of the faces of the other two pair, all of said faces connected electrically and mechanically together and composed of an electrically conductive material, said pickup electrode being centrally located within the transducer;

six drive plates, one drive plate facing one of each face of said pickup electrode, means for supporting said drive plates, each of said drive plates being composed os an electrically conductive material;

a plurality of support springs engaging and supporting said pickup electrode, said support springs arranged in a three dimensional network effective to restrict motion of said pickup electrode to the three orthogonal axes normal to the faces of said pickup plate.

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37. The capacitive transducer of Claim 36, further including: electrical circuit means for applying electrical drive pulses to said drive plates, said pulses having a frequency F, and pulse width T approximately $1/(6*F)$, said drive pulses being grouped into one main channel per operative drive plate pair, there being a total of three drive plate pairs, each of said pair physically positioned on opposite faces of said pickup electrode, each main channel consisting of two sub-channel pulses, one sub-channel pulse operative on each drive plate, with said main channels being multiplexed to sequentially apply said pulses to said drive plates with said main channels being spaced apart in time by approximately the pulse width T, and said two sub-channel signals of the active main channel being applied simultaneously to said drive plate pair;

sampling means for synchronously demodulating the signal on the pickup electrode into three channels, one channel per each of said three drive plate pairs, each channel consisting of two sub-channel signals, one for each drive plate;

timing means for controlling said sampling means such that each first sub-channel is sampled during the time period that the drive pulse is applied to the corresponding drive plate and each second sub-channel is sampled after the drive pulse corresponding to that drive plate has ended, and before the drive pulse corresponding to the next channel is applied;

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storage means for each sub-channel; and
differential amplifier means to convert each of the two sub-channel signal pairs into single main channel signals.

38. The capacitive transducer of Claim 37, wherein each of said main channel signals generated by said differential amplifier means constitutes the outputs of the transducer.

39. The capacitive transducer of Claim 37, wherein each of said main channel signals generated by said differential amplifier means are connected to feedback circuit means which produce feedback signals which control the amplitude of the drive plate pulses in response to displacement of the pickup electrode, such that the induced voltage on the pickup electrode is forced to zero, and the feedback signals generated by said feedback circuit means are proportional to the displacement of the pickup plate.